


## Globalization and the Evolution of the Supply Chain: who gains and who loses?

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journal or publication title	IDE Discussion Paper
volume	5
year	2004-08-01
URL	<a href="http://hdl.handle.net/2344/204">http://hdl.handle.net/2344/204</a>

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## DISCUSSION PAPER No. 5

# Globalization and the Evolution of the Supply Chain: who gains and who loses?\*

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August 2004

### Abstract

This paper focuses on two distinct facets of globalization: the decrease in the trade costs of goods and the decline of communication costs between headquarters and production facilities within firms. When the unskilled have about the same wage in the two regions, the decrease of these costs fosters the gradual agglomeration of plants in the core region accommodating the headquarters. By contrast, when the wage gap is significant, the process of integration eventually triggers the re-location of plants into the periphery. In particular, when the process of re-location is driven by falling communication costs, the welfare of all workers living in the core goes down whereas the welfare of those who reside in the periphery rises.

**Keywords:** information technologies, communication costs, agglomeration, headquarters, plants, supply chain, re-location

**JEL classification:** F12, L13, R13

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\*We thank R. Boucekkine, G. Duranton, R. Feenstra, T. Gokan, R. Ihara, S. Mun, K. Nishikimi, H. Sano, E. Toutlemonde, and D.-Z. Zeng for helpful comments and discussion. This research was supported by the Japanese Ministry of Education and Science (Grant-in-Aid for Science Research 09CE2002 and 13851002) and by the Ministère de l'éducation, de la recherche et de la formation (Communauté française de Belgique), Convention 00/05-262.

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# 1 Introduction

A growing number of firms choose to break down their production process into various stages spread across different countries or regions.<sup>1</sup> Specifically, the firm organizes and performs discrete activities in distinct locations, which altogether form a *supply chain* starting at the conception of the product and ending at its delivery. This spatial fragmentation of production aims at taking advantage of differences in technologies, factor endowments, or factor prices across places (Feenstra, 1998). It is regarded as one of the main ingredients of the process of economic globalization and, as such, has generated harsh debates in most countries. In particular, some policy makers and the general press in industrialized countries tend to view it as the main force driving the growing wage inequality between skilled and unskilled workers. For various groups and nongovernmental organizations, the liberalization of trade and capital flows, which go hand in hand with fragmentation, would also be detrimental to undeveloped countries, by fostering more international economic inequality. Our purpose is to show that globalization need not have such detrimental implications for low-income people and countries.

The most commonly observed pattern corresponding to international fragmentation is such that firms re-locate their production activities in low-wage regions, while keeping their strategic functions (e.g. management, R&D, marketing and finance) concentrated in a few affluent urban regions where the high-skilled workers they need are available. For example, whereas the metropolitan areas of Tokyo and Osaka retain a large number of headquarters, business-to-business service firms and research labs, a growing number of Japanese manufacturing plants move to China where labor is much cheaper (the Chinese/Japanese wage ratio varies from 1/10 to 1/20). This is especially well illustrated by the electronics industry, which is the fastest-growing manufacturing sector in Japan since the mid-1970s. This industry is dominated by nine firms (Hitachi, Matsushita Electric, Toshiba, NEC, Mitsubishi Electric, Fujitsu, Sony, Sanyo Electric, and Sharp), of which total sales in 1990 were almost 200 billion dollars. Fujita and Ishii (1998) report that, from 1975 to 1994, the number of overseas plants located in East Asia has increased from 40 to 143. By contrast, the number of R&D facilities has increased from 24 to 115 in Japan and from 0 to 6 in East Asia. Over the

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<sup>1</sup>This is reflected by the share of expenditures on non-military logistics, which are estimated to 11% of the GDP in the United States (Thomas and Griffin, 1996).

recent period of 1991-1993, the increase in the number of plants located in East Asia has boomed to 29.

Clearly, there is a need for a better understanding of the possible economic consequences of the process of international fragmentation. Within the neoclassical framework of trade theory, its impact on output, wages and welfare has been studied by assuming that fragmentation amounts to some form of technological progress. Not surprisingly, results are often ambiguous because they depend on whether offshore outsourcing takes place in a labor-intensive or in a capital-intensive sector (Jones and Kierzkowski, 2001). However, it has also been argued that international fragmentation shifts up the production possibility frontier of the national economy, thus suggesting that it is always welfare-enhancing (Arndt, 1997). When fragmentation changes prices, Deardoff (2001) qualifies such a statement by showing that the emergence of a supply chain can affect adversely one country by turning its terms of trade against it. Furthermore, even when a country gains from fragmentation, some factor owners in this country may lose.<sup>2</sup>

In this paper, we are interested in studying cross-border fragmentation in a different setting, and so for at least two reasons. First, we believe that imperfect competition suits better the behavior of firms engaged in fragmenting their production than does perfect competition. Second, we allow for labor dualism because the existence of both skilled and unskilled labor is crucial for international fragmentation to arise. To achieve our goal, we therefore use a general equilibrium model of monopolistic competition à la Dixit-Stiglitz that incorporates the following ingredients. Each firm has two units, a headquarter and a single plant. Headquarters use skilled labor whereas plants use headquarter services together with unskilled labor. Each firm is free to decentralize its production overseas by choosing for its plant a location far from its headquarter. Besides its greater realism, this modeling strategy allows us to integrate various ideas within a common framework, which can be solved analytically.

In the literature, the secular decline in transportation and trade costs has been considered as a major element of the process of globalization. We also want to stress the fact that the development of new information and communication technologies is another major force that should be accounted

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<sup>2</sup>Another strand of the literature related to the idea of fragmentation finds its origin in the multinational enterprise. However, it does not address, at least directly, the issues that motivate us (Dunning, 1981; Markusen, 1995; Caves, 1996).

for in order to better understand the evolution of the geography of modern economies. With this in mind, two types of spatial costs are taken into account in our model, namely *communication costs* and *trade costs*. Low trade costs allow firms producing overseas to sell their output on their home market at a low price. Equally important, but perhaps less recognized, is the fact that coordinating activities within the firm is more costly when headquarter workers and plant workers are physically separated. However, lower communication costs make such a coordination easier and, therefore, facilitates the process of fragmentation.<sup>3</sup> How does the spatial division of labor change when communication and trade costs become lower, and what are the corresponding implications for the various groups of workers, are precisely the topics we want to study in this paper.

Management facilities are established in large urban agglomerations because many of the functions in which they are involved require personal communications among skilled workers. These contacts facilitate the transmission of information regarding the development of new products (Duranton and Puga, 2001), while allowing workers of different firms to build the trust required to write incomplete contracts (Leamer and Storper, 2001). Headquarters workers also benefit from the the availability of differentiated local service suppliers and from the proximity of other headquarters and power centers such as governments, trade associations and international agencies (Davis and Henderson, 2003). Even though those various processes may be described at the microeconomic level (Fujita and Thisse, 2002; Duranton and Puga, 2004), for our purpose it is convenient to work with a reduced form such as the one used by Henderson (1988), in which all microeconomic interactions among headquarters' workers are subsumed by means of a simple Marshallian externality that says that the productive efficiency of headquarters rises with the number of firms belonging to the same agglomeration.

For international fragmentation to arise, the intra-firm coordination costs must be sufficiently low so that operating a plant in a distant place is not too costly, whereas trade costs must decrease substantially to permit the supply of large markets at low delivery costs from distant locations. In order to make low-wage areas more accessible and attractive for the setting of their production, firms therefore need the development of new information

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<sup>3</sup>Mokyr (2002) argues convincingly that the existence of high coordination costs was probably the main reason for bringing workers "under the same roof" in the eves of the Industrial Revolution.

and communication technologies as well as a substantial fall in trade costs. Interestingly, this is precisely what we have witnessed during the last decades.

Previewing our main results, we study in section 3 how plants are distributed between the two regions when all headquarters are set up in one region. As said above, globalization has two main facets in that it goes hand in hand with lower trade barriers as expressed through decreasing tariffs and transportation costs, on the one hand, and lower communication costs between headquarters and plants generated by the development of the new information and communication technologies, on the other. In section 4, we show that all plants are located with their headquarters when communication costs are sufficiently high. In this case, all firms are national and established in the core region. Once communication costs steadily decrease, the industry moves toward a configuration in which *some firms are multinational whereas others are national*. Note that an equilibrium involving firms of different types does not suggest itself because firms are a priori identical. It comes about as the spatial division of labor changes with the level of communication costs.<sup>4</sup> Eventually, when these costs have reached a sufficiently low level, the economy ends up with a deindustrialized core that retains only firms' strategic functions.

A fall in trade costs may lead to fairly contrasted patterns of production. When communication costs are high, reducing trade costs leads to a growing agglomeration of plants within the core, very much as in the core-periphery model developed by Krugman (1991). However, the agglomeration process is here gradual instead of exhibiting a bang-bang behavior. Things are totally different when communication costs are low. For high trade costs, most plants are still located within the core region. However, once trade costs fall below some threshold, the re-location process unfolds over a small range of trade cost values. This observation could explain why the process of deindustrialization of some developed countries seems, first, to be slow and, then, to proceed quickly, yielding a space-economy very different from the initial one. Thus, our model seems to support a (partial) deindustrialization of the core region, unless new activities are developed there.

Finally, our framework allows us to study the impact of the reduction in intrafirm coordination costs on the welfare of workers. As more plants

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<sup>4</sup>Such a mixed configuration of firms is reminiscent of what was observed in the 19th century, when (centralized) factories and (decentralized) putting-out trades coexist over a long time period, even in England (Mokyr, 2002).

move into the periphery, the unskilled workers residing there are better off whereas the unskilled living in the core are worse off, as expected. Totally unexpected (at least to us) is the outcome that the skilled working in the management facilities located within the core are also hurt by the fragmentation of firms. Indeed, even though their nominal wage is unaffected, they suffer from an increase in the local price index. Accordingly, both types of workers living in the core are worse off when firms gradually relocate their plants into the periphery. Although each firm gets fragmented in the pursuit of its own interest, such a strategy might hurt them all, as if “going multinational” were to obey a prisoner’s dilemma. Hence, once it is recognized that the market economy is imperfectly competitive, the process of fragmentation can be harmful to both the skilled and unskilled workers living in the core. By contrast, it would be beneficial to the workers located in the periphery. As a result, *fragmentation would contribute to narrowing the gap between rich and poor countries*. Hence, our paper suggests that one of the main engines of globalization - fragmentation - might well have redistributive consequences that vastly differ from those expected by the anti-globalization demonstrators. It also runs against the popular idea that the internalization of production would lie at the origin of the observed inequality between skilled and unskilled workers in developed countries.

These results may (partially) rest on some particularities of the Dixit-Stiglitz model. However, it should be kept in mind that this model is the workhorse of most recent theories of trade and growth. So our results cannot be dismissed on that basis only. Although more work is called for, our analysis could provide possible insights regarding, for example, the relative stagnation of the today’s Japanese economy, which has been experiencing a large re-location flow of its industrial plants toward China and other developing countries.

The remainder of the paper is organized as follows. The model is presented in section 2 whereas the equilibrium is characterized in section 3. In section 4, we study the impact of decreasing communication and trade costs on the market outcome. The welfare impact of falling communication costs is dealt with in section 5. Section 6 concludes.



## 2 The model

The economic space is made of two regions,  $A$  and  $B$ . There are two production factors, the high-skilled workers and the low-skilled workers whose populations are given. The skilled workers are perfectly mobile between regions whereas the unskilled are immobile. The economy has two sectors, the modern sector (**M**) and the traditional sector (**T**). The **M**-sector produces a continuum of varieties of a horizontally differentiated product under increasing returns. Each variety of the **M**-sector is produced by a single firm, using both skilled and unskilled labor. Specifically, each firm has a *headquarter*, which uses skilled workers to produce services that are firm-specific assets à la Williamson, and operates a *single plant*, using headquarter services and unskilled workers to produce its variety. The headquarter and production facility of a firm need not be located together. When both are located in the same region, the firm is *national*; when they are not, the firm is *multi-national*. Hence, the fragmentation of the firm is only vertical. The **T**-sector produces a homogeneous good under constant returns, using unskilled labor as the only input.

Preferences are identical across all workers and described by a Cobb-Douglas utility:

$$U = Q^\mu \Upsilon^{1-\mu} / \mu^\mu (1-\mu)^{1-\mu} \quad 0 < \mu < 1 \quad (1)$$

where  $Q$  stands for an index of the consumption of the modern sector varieties, while  $\Upsilon$  is the consumption of the output of the traditional sector. Because the modern sector provides a continuum of differentiated varieties of size  $m$ , the index  $Q$  is given by

$$Q = \left[ \int_0^m q(i)^\rho di \right]^{1/\rho} \quad 0 < \rho < 1 \quad (2)$$

where  $q(i)$  represents the consumption of variety  $i \in [0, m]$ . In (2), the parameter  $\rho$  stands for the inverse of the intensity of love for variety over the differentiated product. When  $\rho$  is close to 1, varieties are close to perfect substitutes; when  $\rho$  decreases, the desire to spread consumption over all varieties increases. If we set

$$\sigma \equiv \frac{1}{1-\rho}$$

then  $\sigma$  is the elasticity of substitution between any two varieties, which varies between 1 and  $\infty$ . Since there is a continuum of firms, each firm is negligible

and the interactions between any two firms are zero, but aggregate market conditions (e.g., the average price across firms) affects each firm.

If  $Y$  denotes the consumer income,  $p^{\mathbf{T}}$  the price of the traditional good, and  $p(i)$  the price of variety  $i$ , then the demand functions are

$$\Upsilon = (1 - \mu)Y/p^{\mathbf{T}} \quad (3)$$

$$q(i) = \frac{\mu Y}{p(i)} \frac{p(i)^{-(\sigma-1)}}{P^{-(\sigma-1)}} = \mu Y p(i)^{-\sigma} P^{\sigma-1} \quad i \in [0, m] \quad (4)$$

where  $P$  is the price index of the differentiated product given by

$$P \equiv \left[ \int_0^m p(i)^{-(\sigma-1)} di \right]^{-1/(\sigma-1)} \quad (5)$$

Introducing (3) and (4) into (1) yields the indirect utility function

$$v = Y P^{-\mu} (p^{\mathbf{T}})^{-(1-\mu)} \quad (6)$$

Technologies in each of the two sectors differ from what is usually assumed in economic geography models. The technology in the **T**-sector is such that one unit of output requires  $a_r \geq 1$  units of unskilled labor in region  $r = A, B$ . Without loss of generality, we set  $a_A = 1$  and  $a_B \geq 1$ , thus allowing unskilled workers in the traditional sector to be more productive in region  $A$  than in region  $B$ . Let  $L_A$  and  $L_B$  be the number (mass) of unskilled workers in region  $A$  and  $B$ , respectively. In order to retain the standard assumption of symmetry between the two regions, we assume that the spatial distribution of unskilled workers is such that both regions have the same amount of effective units of unskilled labor, denoted  $L/2$ :

$$L_A = \frac{L_B}{a_B} = \frac{L}{2} \quad (7)$$

The output of the **T**-sector is costlessly traded between the two regions, thus implying that its price is the same across regions. It is chosen as the numéraire so that  $p^{\mathbf{T}} = 1$ . We further assume that the expenditure share  $(1-\mu)$  on the **T**-good is sufficiently large for the **T**-good to be always produced in both regions.<sup>5</sup> In this case, the equilibrium wages for the unskilled are such that

$$w_A^L = 1 \quad w_B^L = 1/a_B \leq 1 \quad (8)$$

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<sup>5</sup> A sufficient condition for this to hold is that  $\mu < 1/(1 + \rho)$ .

In other words, our model allows us to cope with *a given wage differential across regions* for the unskilled workers.<sup>6</sup> Hence, there is a factor-price motive that may explain vertical fragmentation. However, as will be seen below, factor price differential is not the only reason for the multinationalization of firms.

The technology of the **M**-sector is more involved. As said above, each firm has a headquarter as well as a production plant, and both may be separated in space. The setting of a headquarter (HQ) requires a fixed amount  $f$  of skilled labor. Because each firm needs a headquarter and because skilled workers are used only by headquarters, the total number (mass) of firms in the economy is given by

$$m = S/f$$

where  $S$  is the total number of skilled workers.

When the HQ is located in region  $r$  and the plant in region  $s$ , producing  $q(i)$  units of variety  $i$  requires  $l(i)$  units of unskilled labor:

$$l(i) = c_{rs}q(i)$$

where  $c_{rs} > 0$  is the plant's marginal labor requirement, whereas the fixed cost associated with the operation of a plant is subsumed in the parameter  $f$  defined above. The value of  $c_{rs}$  decreases with the effectiveness of the services provided by the HQ to its plant, which depends itself on the following two factors. First, the agglomeration of HQs within the same region generates Marshallian externalities which make the HQ of firm  $i$  more effective in its supply of services. This implies that  $c_{rs}$  decreases with the number  $m_r \geq 0$  of HQs established in region  $r$ . Second, the distance between the HQ and its plant affects negatively the effectiveness of the HQ-services. More precisely, let  $c(m)$  be a decreasing function of  $m$  such that  $c(\infty) > 0$ . Then, when both the HQ and the plant are located in the same region ( $r = s$ ) we have

$$c_{rr} = c(m_r)$$

whereas, when they are located in different regions, we have

$$c_{rs} = c(m_r)T_C \quad \text{for } r \neq s$$

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<sup>6</sup>Note that (8) also implies that the evolution of relative wages between skilled and unskilled workers is obtained by determining how the earnings of the skilled vary.

where  $T_C > 1$  accounts for all the impediment to coordination within the firm when the HQ and plant are physically separated. When the information to transfer is not easily codified, we may expect  $T_C$  to be large. The cost  $T_C$  also rises with the uncertainty associated with conducting business in a distant location.

As a result, when the plant is located with its HQ in region  $r$ , the plant production function is given by

$$l(i) = c(m_r)q(i) \quad r = s$$

By contrast, when the plant is set up in a different region, we have:

$$l(i) = c(m_r)T_C q(i) \quad r \neq s$$

This specification has two important implications. First, when the plant is separated from its HQ, it is less efficient and, thus, needs a larger amount of local input. So we recognize that the physical separation of headquarters and plants generates a cost for firms; however, we also recognize that the corresponding cost  $T_C$  may decrease with the development of new communication technologies. Second, as long as the level of HQ-services is the same, unskilled workers are equally productive once they work in firms belonging to the modern sector. This is because firms are able to organize their production in the same way whatever the plant's location.<sup>7</sup> Furthermore, because of the existence of a perfectly competitive traditional sector in each of the two regions, the nominal wages of the unskilled (8) are unaffected by the re-location of the industrial plants. As will be seen in section 5, this is not true for their real wages.

As usual, the output of the **M**-sector is shipped at a positive cost according to an iceberg technology à la Samuelson (1954): when one unit of any variety of the differentiated product is moved from region  $r$  to region  $s \neq r$ , only a fraction  $1/T_M$  arrives at destination with  $T_M > 1$ . Within each region, transportation is costless. Hence, if variety  $i$  is produced in region  $r$  and sold at the mill (fob.) price  $p_r(i)$ , the price paid by a consumer located in region  $s$  ( $\neq r$ ) is  $p_r(i)T_M$ .

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<sup>7</sup>Note that the main conclusions drawn in section 4 hold true if the productivity of the unskilled working for the modern sector is lower in region  $B$  than region  $A$ . This can be achieved by multiplying  $T_C$  by a positive constant accounting for the productivity difference in the modern sector.

Let  $w_r^H$  be the wage earned by skilled workers in region  $r$ . Then, using (7) and (8) the total income of region  $r$  is such that

$$Y_r = m_r f w_r^H + L/2 \quad r = A, B \quad (9)$$

Using (4), the total demand for variety  $i$  produced in region  $r$  can be shown to be given by the following expression:

$$q_r(i) = \mu Y_r p_r(i)^{-\sigma} P_r^{\sigma-1} + \mu Y_s [p_r(i) T_M]^{-\sigma} P_s^{\sigma-1} T_M \quad (10)$$

where  $P_r$  (resp.,  $P_s$ ) stands for the price index of the differentiated good in regions  $r$  (resp.,  $s$ ), which is defined later.

Because there is a continuum of firms, each one is negligible in the sense that its action has no impact on the market. Hence, when choosing its prices, a firm located in  $r$  accurately neglects the impact of its decision over the two price indices  $P_r$  and  $P_s$ . In addition, because firms sell differentiated varieties, each one has some monopoly power and faces the demand function (10). Let  $M_{rs}$  (resp.,  $m_{rs}$ ) be the set (resp., the number) of firms whose headquarters are in region  $r$  and plants in region  $s$ , with  $r, s = A, B$ . The profit of firm  $i \in M_{rr}$  is as follows:

$$\pi_{rr}(i) = p_r(i) q_r(i) - w_r^H f - w_r^L c(m_r) q_r(i)$$

so that the equilibrium mill price charged by firm  $i$  in region  $r$ :

$$p_r^*(i) = \frac{w_r^L c(m_r)}{\rho} \quad i \in M_{rr} \quad (11)$$

Similarly, the profit of a firm  $i \in M_{rs}$  with  $r \neq s$  is as follows:

$$\pi_{rs}(i) = p_s(i) q_s(i) - w_r^H f - w_s^L c(m_r) T_C q_s(i)$$

so that the equilibrium mill price charged by the plant located in region  $s$  is

$$p_s^*(i) = \frac{w_s^L c(m_r) T_C}{\rho} \quad i \in M_{rs} \quad \text{and} \quad r \neq s \quad (12)$$

Comparing (11) and (12) reveals that the equilibrium prices of the same variety produced in either of the two regions differ not only because of the wage differential for the unskilled, but also because of the higher communication

costs ( $T_C$ ) of the HQ-services that a firm must incur when it decentralizes its production.

Using (5), (7) and (8), we may determine the regional price index in region  $r$  as follows:

$$P_r = \left\{ m_{rr} \left( \frac{w_r^L c(m_r)}{\rho} \right)^{-(\sigma-1)} + m_{sr} \left( \frac{w_r^L c(m_s) T_C}{\rho} \right)^{-(\sigma-1)} + T_M^{-(\sigma-1)} \left[ m_{rs} \left( \frac{w_s^L c(m_r) T_C}{\rho} \right)^{-(\sigma-1)} + m_{ss} \left( \frac{w_s^L c(m_s)}{\rho} \right)^{-(\sigma-1)} \right] \right\}^{-1/(\sigma-1)}$$

in which the first two terms account for the varieties produced in region  $r$  and the last two for those produced in  $s$ . The real wage, or the indirect utility (6), of the unskilled and of the skilled workers is respectively defined by

$$\begin{aligned} \omega_r^L &= w_r^L / P_r^\mu & r = A, B \\ \omega_r^H &= w_r^H / P_r^\mu & r = A, B \end{aligned}$$

Finally, for a given distribution of HQs and plants between the two regions, the equilibrium profits may be obtained as follows:

$$\begin{aligned} \pi_{rr}^* &= k_1 [w_r^L c(m_r)]^{-(\sigma-1)} (Y_r P_r^{\sigma-1} + Y_s P_s^{\sigma-1} T_M^{-(\sigma-1)}) - w_r^H f \\ \pi_{rs}^* &= k_1 [w_s^L c(m_r) T_C]^{-(\sigma-1)} (Y_r P_r^{\sigma-1} T_M^{-(\sigma-1)} + Y_s P_s^{\sigma-1}) - w_r^H f \quad r \neq s \end{aligned}$$

where

$$k_1 \equiv \frac{\mu(\sigma-1)^{\sigma-1}}{\sigma^\sigma}$$

is a positive constant. Hence, the free entry condition becomes

$$\max \{ \pi_{AA}^*, \pi_{AB}^*, \pi_{BB}^*, \pi_{BA}^* \} = 0$$

which implies that the wage paid to the skilled working in HQs comes from the operating profits earned by plants. As mentioned in the introduction, the fragmentation of the firm therefore gives rise to a interregional transfer of profits from the plant to the HQ.

### 3 Spatial equilibrium when the HQs are agglomerated

For the reasons discussed in the introduction, we focus on the pattern in which all HQs are located within the same region. Because the unskilled in region  $A$  are more productive than those in region  $B$ , they are paid a higher nominal wage. Therefore, since firms are driven by nominal wages, as trade costs fall, it seems reasonable to expect the re-location of plants into region  $B$ . This opens the door to the possible separation of HQs in region  $A$ , which we call the *core*, and of plants in region  $B$ , called the *periphery* of the global economy. In this section, we are interested in the way production facilities are distributed between these two regions.

The assumption above regarding the location of HQs implies that  $m_A = m$ ,  $m_B = 0$ ,  $m_{BA} = m_{BB} = 0$ , and  $m_{AA} + m_{AB} = m$ . In what follows, we are interested in the way production facilities are distributed between the two regions as well as in the impact of decreasing trade costs ( $T_M$ ) and communication costs between HQs and plants ( $T_C$ ) under the presence of a given wage differential ( $a_B > 1$ ). To this effect, it will appear convenient to use the following notation:

$$\theta \equiv \frac{m_{AA}}{m} \quad \phi_C \equiv (T_C/a_B)^{-(\sigma-1)} \quad \phi_M \equiv T_M^{-(\sigma-1)}$$

Observe that  $\phi_M$  varies between 0 (prohibitive trade costs) and 1 (zero trade costs) and, therefore, measures the degree of integration between the two regions. By contrast,  $\phi_C$  varies from 0 (prohibitive communication costs) to  $a_B^{\sigma-1} > 1$  (zero communication costs) for a fixed value of  $a_B > 1$ . Hence,  $\phi_C$  may be interpreted as an index of the degree of decentralization within each firm, which accounts for both the communication costs and the unskilled wage differential. In what follows, we will describe the equilibrium configurations for all possible values of  $\phi_C > 0$  because the value of  $a_B^{\sigma-1}$  may be very large. However, the reader should keep in mind the fact that, once  $\phi_C$  has reached its upper bound  $a_B^{\sigma-1}$ , the corresponding configuration will be the ultimate one in the global economy. Stated differently, the entire process does not unfold and stops as soon as  $\phi_C = a_B^{\sigma-1}$ .

The HQs being located in region  $A$ , the price indices boil down to:

$$P_A = \frac{c(m)}{\rho} m^{-1/(\sigma-1)} [\theta + (1-\theta)\phi_C\phi_M]^{-1/(\sigma-1)} \quad (13)$$

$$P_B = \frac{c(m)}{\rho} m^{-1/(\sigma-1)} [\theta\phi_M + (1-\theta)\phi_C]^{-1/(\sigma-1)} \quad (14)$$

whereas regional incomes and profits become respectively

$$Y_A = Sw_A^H + L/2 \quad Y_B = L/2$$

and

$$\pi_{AA}^* = \frac{\mu f}{\sigma S} \left[ \frac{Sw_A^H + L/2}{\theta + (1-\theta)\phi_C\phi_M} + \frac{L/2}{\theta + (1-\theta)\phi_C\phi_M^{-1}} \right] - w_A^H f \quad (15)$$

$$\pi_{AB}^* = \frac{\mu f}{\sigma S} \left[ \frac{Sw_A^H + L/2}{\theta\phi_C^{-1}\phi_M^{-1} + (1-\theta)} + \frac{L/2}{\theta\phi_C^{-1}\phi_M + (1-\theta)} \right] - w_A^H f \quad (16)$$

The equilibrium conditions for the HQs to be agglomerated in region A and the plants to be dispersed between the two regions are obtained in three steps. We first determine the conditions for plants to be located in both regions (Step 1), whereas we deal with the two extreme cases in which all plants are located in the core or in the periphery in Step 2. Finally, Step 3 identifies a sufficient condition for all the HQs to be agglomerated in the core.

**Step 1.** We solve the equilibrium conditions when  $\pi_{AA}^* = \pi_{AB}^* = 0$  and determine the corresponding  $(\phi_C, \phi_M)$ -domain. The condition  $\pi_{AA}^* = 0$  yields:

$$w_A^H = \frac{\mu L}{\sigma S} \frac{\theta + (1-\theta)\phi_C(\phi_M + \phi_M^{-1})/2}{[\theta + (1-\theta)\phi_C\phi_M - \mu/\sigma][\theta + (1-\theta)\phi_C\phi_M^{-1}]} \quad (17)$$

Furthermore, the condition  $\pi_{AB}^* = 0$  leads to

$$\frac{\phi_C\phi_M^{-1} - 1}{1 - \phi_C\phi_M} \cdot \frac{\theta + (1-\theta)\phi_C\phi_M}{\theta + (1-\theta)\phi_C\phi_M^{-1}} = 1 + \frac{2Sw_A^H}{L} \quad (18)$$

Solving (17) and (18) for  $\theta$ , we obtain

$$\theta(\phi_C, \phi_M) \equiv \frac{\frac{1+\mu/\sigma}{2}\phi_M^{-1} + \frac{1-\mu/\sigma}{2}\phi_M - \phi_C}{\phi_M^{-1} + \phi_M - (\phi_C^{-1} + \phi_C)} \quad (19)$$

which is well defined provided that the denominator is nonzero, that is,  $\phi_C \neq \phi_M$  and  $\phi_C\phi_M \neq 1$ . Assuming that these two conditions hold, differentiating (19) with respect to  $\phi_C$  yields

$$\frac{\partial\theta(\phi_C, \phi_M)}{\partial\phi_C} = -\frac{F(\phi_C, \phi_M)}{(\phi_M^{-1} + \phi_M - \phi_C^{-1} - \phi_C)^2} \quad (20)$$



where

$$F(\phi_C, \phi_M) \equiv \left( \frac{1 - \mu/\sigma}{2} \phi_M^{-1} + \frac{1 + \mu/\sigma}{2} \phi_M \right) + \left( \frac{1 + \mu/\sigma}{2} \phi_M^{-1} + \frac{1 - \mu/\sigma}{2} \phi_M \right) \phi_C^{-2} - 2\phi_C^{-1} \quad (21)$$

It is shown in the appendix that  $F(\phi_C, \phi_M)$  is always positive so that (20) is always negative for any fixed value of  $\phi_M < 1$  when the denominator of (19) is nonzero.

We must now determine the conditions under which  $0 \leq \theta(\phi_C, \phi_M) \leq 1$ . For this purpose as well as for the rest of the analysis, it will appear to be convenient to use the *iso-share curves* defined as follows:

$$\theta(\phi_C, \phi_M) = \theta \quad \text{for any } \theta \in [0, 1]$$

Solving this equation for  $\phi_C$ , it is readily verified that this solution, denoted  $\phi_C(\phi_M; \theta)$ , always exists and is unique:

$$\phi_C(\phi_M; \theta) = \frac{g(\phi_M; \theta) + \sqrt{g^2(\phi_M; \theta) + 4\theta(1 - \theta)}}{2(1 - \theta)} \quad \text{for any } \theta \in [0, 1] \quad (22)$$

where

$$g(\phi_M; \theta) \equiv \left( \frac{1 + \mu/\sigma}{2} - \theta \right) \phi_M^{-1} + \left( \frac{1 - \mu/\sigma}{2} - \theta \right) \phi_M \quad (23)$$

whereas, for  $\theta = 1$

$$\phi_C(\phi_M; 1) = \left( \frac{1 - \mu/\sigma}{2} \phi_M^{-1} + \frac{1 + \mu/\sigma}{2} \phi_M \right)^{-1} \quad (24)$$

Two specific iso-share curves turn out to be of special importance: the *unit iso-share curve* given by (24) and the *zero iso-share curve* corresponding to  $\theta = 0$ , that is,

$$\phi_C(\phi_M; 0) = g(\phi_M; 0) \equiv \frac{1 + \mu/\sigma}{2} \phi_M^{-1} + \frac{1 - \mu/\sigma}{2} \phi_M \quad (25)$$

These two curves are depicted in Figure 1 by the top and bottom bold lines.

Figure 1: Iso-share curves for plant distribution

It is easy to check that

$$\phi_C(1; \theta) = 1 \quad \text{for any } \theta \in [0, 1]$$

$$\left. \frac{\partial \phi_C(\phi_M; \theta)}{\partial \phi_M} \right|_{\phi_M=1} = -\mu/\sigma \quad \text{for any } \theta \in [0, 1]$$

These properties state that, for all admissible values of  $\theta$ , all iso-share curves go through 1 when  $\phi_M = 1$  and have the same negative slope.

We are now ready to solve our problem. Let

$$\Phi \equiv \{(\phi_C, \phi_M); \phi_C(\phi_M; 1) < \phi_C < \phi_C(\phi_M; 0), 0 < \phi_M < 1\}$$

be the  $(\phi_C, \phi_M)$ -domain delineated by the top and bottom bold lines of Figure 1. It is readily verified that  $\Phi$  is included in the set defined by the two inequalities

$$\phi_M < \phi_C < \phi_M^{-1} \quad (26)$$

Hence, it must be that  $\phi_C \neq \phi_M$  and  $\phi_C \phi_M \neq 1$  when  $(\phi_C, \phi_M) \in \Phi$ . This implies that the denominator of (19) is always nonzero on  $\Phi$ . As  $\theta(\phi_C, \phi_M)$  is decreasing with respect to  $\phi_C$  over  $\Phi$ , it follows that  $\theta(\phi_C, \phi_M) \in (0, 1)$  if and only if  $\phi_C(\phi_M; 1) < \phi_C < \phi_C(\phi_M; 0)$ . Finally, it can be shown that  $\theta(\phi_C, \phi_M)$  is continuous over the closure of  $\Phi$ . Hence,  $\theta(\phi_C, \phi_M) \in [0, 1]$  if and only if  $\phi_C(\phi_M; 1) \leq \phi_C \leq \phi_C(\phi_M; 0)$  because all the corresponding iso-share curves are included in the closure of  $\Phi$ .

It remains to determine the equilibrium wage. Substituting (19) in (17) yields after several simplifications:

$$w_A^H = \frac{L}{S} \frac{\mu/\sigma}{1 - \mu/\sigma} \quad (27)$$

which is always positive. The fact that  $w_A^H$  is independent of  $\phi_C$  (as well as of  $\phi_M$ ) means that firms react to a decrease in communication costs by adjusting noncooperatively the location of their plants in order to keep the level of their nominal operating profits constant. Note, however, that  $w_A^H$  rises with the share of the industrial sector ( $\mu$ ), the degree of product differentiation of its output ( $1/\sigma$ ) as well as with the ratio between the unskilled and skilled workers ( $L/S$ ).

**Step 2.** In the South-East area of Figure 1 below the bottom bold line, it is readily verified that  $\pi_{AA}^* = 0 > \pi_{AB}^*$ , which means that all plants are agglomerated in the core ( $\theta^* = 1$ ). In this domain, setting  $\theta^* = 1$  in (17)

yields somewhat unexpectedly, the same expression as (27) for the nominal wage of the skilled workers.

Likewise, in the North-East domain of Figure 1 above the top bold line, we have  $\pi_{AB}^* = 0 > \pi_{AA}^*$  so that all plants are located in the periphery ( $\theta^* = 0$ ). Setting  $\theta^* = 0$  in (16) and solving for  $w_A^H$  yields again (27) for the nominal wage of the skilled workers. Thus, *regardless of the equilibrium pattern of plant distribution, the nominal wage of the skilled workers is given by (27), which is itself independent of the values of trade and communication costs.*

This unexpected result may be explained as follows. First, because the nominal wage of unskilled labor in efficiency units is normalized to one in both regions, the nominal income of each region is given by (9) with  $m_A = m$  and  $m_B = m$ , which does not depend on  $T_M$  and  $T_C$ . Second, when communication costs decrease, (11) implies that a firm with a plant in region  $B$  becomes more competitive. But, as the same holds for all multinational firms, the reduction in communication costs also makes the firm in question less competitive. In the present context, these two opposite effects just cancel out, thus implying that the firm's profits are unaffected. The same story applies to a decrease in trade costs. Consequently, the level of equilibrium profits made by a firm are unaffected by changes in trade and communication costs. This in turn implies that the zero-profit equilibrium wage of the skilled remains constant.

**Step 3.** It remains to determine when the equilibrium conditions  $\pi_{BB}^* \leq 0$  and  $\pi_{BA}^* \leq 0$  are satisfied. Since all skilled workers are to be in region  $A$ , it must be that  $\omega_A^H \geq \omega_B^H$ . Without loss of generality, we may assume that  $\omega_A^H = \omega_B^H$ , which amounts to

$$w_A^H = \frac{P_B^\mu}{P_A^\mu} w_B^H$$

Consider first the  $(\phi_C, \phi_M)$ -domain for which  $\pi_{AA}^* = \pi_{AB}^* = 0$ . Using  $\pi_{AB}^* = 0$ , it is then readily verified that  $\pi_{BB}^* \leq 0$  holds if and only if

$$\left[ \frac{c(0)}{c(m)} \right]^{\sigma-1} \geq \left[ \frac{\theta^* \phi_M + (1 - \theta^*) \phi_C}{\theta^* + (1 - \theta^*) \phi_C \phi_M} \right]^{\mu/(\sigma-1)} T_C^{\sigma-1} \quad (28)$$

Similarly, using  $\pi_{AA}^* = 0$ ,  $\pi_{BA}^* \leq 0$  holds if and only if

$$\left[ \frac{c(0)}{c(m)} \right]^{\sigma-1} \geq \left[ \frac{\theta^* \phi_M + (1 - \theta^*) \phi_C}{\theta^* + (1 - \theta^*) \phi_C \phi_M} \right]^{\mu/(\sigma-1)} T_C^{-(\sigma-1)}$$

which is always satisfied when (28) holds. Note that the right hand side of (28) is strictly decreasing in  $\theta^*$  so that  $\pi_{BB}^* \leq 0$  and  $\pi_{BA}^* \leq 0$  hold as long as (28) is satisfied for  $\theta^* = 1$ , that is,

$$\frac{c(0)}{c(m)} \geq \frac{T_C}{T_M^{\mu/(\sigma-1)}} \quad (29)$$

In words, *all firms choose to agglomerate their HQs in region A when the Marshallian externalities are sufficiently strong with respect to the communication cost over the trade cost.*<sup>8</sup> This is likely to hold when communication costs are not too high compared to trade costs.

Likewise, in the  $(\phi_C, \phi_M)$ -domain for which either  $\pi_{AA}^* = 0 > \pi_{AB}^*$  or  $\pi_{AB}^* = 0 > \pi_{AA}^*$  hold, it is easy to see that (29) always assures that  $\pi_{BB}^* \leq 0$  and  $\pi_{BA}^* \leq 0$ .

To sum-up, we have shown the following result.

**Proposition 1** *Assume that (29) holds. Then, the configuration in which all HQs are agglomerated in region A, whereas  $m\theta^*$  plants are located in A and  $m(1 - \theta^*)$  plants in B is a spatial equilibrium, where  $\theta^*$  is given by*

$$\theta^* = \begin{cases} 1 & \text{if } \phi_C \leq \phi_C(\phi_M; 1) \\ \theta(\phi_C, \phi_M) & \text{if } \phi_C(\phi_M; 1) < \phi_C < \phi_C(\phi_M; 0) \\ 0 & \text{if } \phi_C(\phi_M; 0) \leq \phi_C \end{cases}$$

## 4 The impact of economic integration on the distribution of plants

In this section, we explore the impact of decreasing trade costs of the differentiated product ( $\phi_M$  increases) as well as decreasing communication costs between HQs and plants ( $\phi_C$  increases), assuming that Marshallian externalities are strong enough for (29) to always hold.

To this end, we introduce the *critical iso-share curve* obtained when  $\theta(\phi_C, \phi_M) = (1 + \mu/\sigma)/2 \equiv \theta_c$ , that is,

$$\phi_C(\phi_M; \theta_c) = \frac{\mu/\sigma}{1 - \mu/\sigma} \left[ \sqrt{\phi_M^2 + (\sigma/\mu)^2} - 1 - \phi_M \right] \quad (30)$$

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<sup>8</sup>In the right hand side of (29),  $T_C$  represents the saving in communication costs when the HQ of a firm moves from region A to B while keeping its plant in B, whereas the term  $T_M^{\mu/(\sigma-1)}$  reflects the increase in the price index of M-goods for the skilled workers who move to B with their HQ.

which is depicted in Figure 1 by the middle bold line. Furthermore, we also have

$$\lim_{\phi_M \rightarrow 0} \theta(\phi_C, \phi_M) = \frac{1 + \mu/\sigma}{2} \quad \text{for any } \phi_C > 0$$

which implies that both the vertical axis and the critical iso-share curve yield the same share  $(1 + \mu/\sigma)/2$ . Finally, for any  $\theta > (1 + \mu/\sigma)/2$ , it is easy to check that iso-share curves are single-peaked with a maximum reached at

$$\phi_M(\theta) = \sqrt{\frac{(2\theta - 1) - \mu/\sigma}{(2\theta - 1) + \mu/\sigma}}$$

which is obtained by equating to zero the first derivative of (22), which turns out to be the solution of  $\partial g / \partial \phi_M = 0$ , where  $g$  is given by (23). Clearly,  $\phi_M(\theta)$  increases from 0 at  $\theta = (1 + \mu/\sigma)/2$  to  $[(1 - \mu/\sigma)/(1 + \mu/\sigma)]^{1/2}$ , while the corresponding value of  $\phi_C[\phi_M(\theta); \theta]$  decreases along the broken line of Figure 1 from  $[(1 + \mu/\sigma)/(1 - \mu/\sigma)]^{1/2}$  to  $[(1 - (\mu/\sigma)^2)]^{-1/2}$ . When  $\theta < (1 + \mu/\sigma)/2$ , each iso-share curve is monotonistically decreasing from infinity to 1.

## 4.1 Reducing communication costs

Assume that  $\phi_C$  and  $\phi_M$  are such that  $0 < \theta^* < 1$  and consider a decrease in communication costs between firms' HQ and plant, as measured by a rise of  $\phi_C$ . Taking the distribution of plants  $\theta^* \in (0, 1)$  as fixed, the rise in  $\phi_C$  has a simple direct effect: international firms now charge a lower price (12) because their marginal cost is lower, whereas national firms stick to the same price as before (11). Consequently, international firms increase their market share in each region at the expense of national firms. Profits being zero before  $\phi_C$  rose, this implies that

$$\pi_{AA}^* < 0 < \pi_{AB}^*$$

In other words, firms whose plants are located in region  $A$  now make negative profits whereas those whose plants are located in region  $B$  earn positive profits. Accordingly, *reducing communication costs give to some integrated firms an incentive to become fragmented*.

Moving some plants into region  $B$  restore the profits of the integrated

firms and reduce those of the fragmented firms. Indeed, using (26), we get

$$\begin{aligned}\frac{\partial \pi_{AA}^*}{\partial \theta} &= -\frac{\mu f (Sw_A^H + L/2)(1 - \phi_C \phi_M)}{\sigma S [\theta + (1 - \theta)\phi_C \phi_M]^2} \frac{(1 - \theta)(\phi_M^{-1} - \phi_M)}{\theta \phi_C^{-1} + (1 - \theta)\phi_M^{-1}} < 0 \\ \frac{\partial \pi_{AB}^*}{\partial \theta} &= -\frac{\theta}{1 - \theta} \frac{\partial \pi_{AA}^*}{\partial \theta} > 0\end{aligned}$$

Hence, national firms restore their profits when there are less of them. This is because the price index in the core rises when  $\phi_C$  increases (see (31) below), thus allowing firms that remain national to have higher demands in the core, hence higher profits. Similarly, international firms' profits decrease when more firms are fragmented because the price index in the periphery decreases when  $\phi_C$  increases, so that international firms have a lower demand in the periphery, hence lower profits. As a result, for an given value  $\phi_M < 1$ , *reducing intrafirm communication costs leads to a gradual increase in the share of plants located in the periphery.*

As shown by Figure 1, when communication costs are sufficiently high, all plants are set up in the core region ( $\theta^* = 1$ ). Once  $\phi_C$  is sufficiently large for the unit iso-share curve to be hit, further decreases in communication costs trigger a re-location of plants into the periphery. Up to the critical iso-share curve, however, more than half of the plants stick to the core region ( $\theta^* > (1 + \mu/\sigma)/2$ ). When communication costs fall below that value, eventually all plants end up being located in the periphery ( $\theta^* = 0$ ).

It is worth stressing the fact that *the re-location process is affected by the value of the trade costs*. When trade costs decrease from sufficiently large values (that is,  $\phi_M$  is small but increasing), Figure 1 reveals that all plants remain in the core for a wider range of  $\phi_C$ -values, whereas the domain over which the transition occurs shrinks. When  $\phi_M$  reaches the value

$$\sqrt{\frac{1 - \mu/\sigma}{1 + \mu/\sigma}}$$

the domain of  $\phi_C$ -values for which plants are agglomerated in the core also shrinks, thus implying that the re-location process starts earlier. The larger the share of the modern sector, the larger the degree of product differentiation across varieties, or both, the larger the domain over which all plants are agglomerated in the core.

The discussion above may then be summarized as follows.

**Proposition 2** *Assume any given positive value of the trade costs. When communication costs are sufficiently high, all plants are located with their headquarters. When these costs become sufficiently low, the share of plants located in the core starts decreasing. If communication costs keep decreasing, the re-location process goes on monotonically until all firms are multinational.*

## 4.2 Reducing trade costs

The impact of a decrease in trade costs (which is measured by a rise of  $\phi_M$ ) is more involved because it depends on the value of intrafirm communication costs in a nonlinear way. When  $\phi_C \leq 1$  (or  $T_C/a_B \geq 1$ ), it is readily verified that reducing trade costs leads to a growing agglomeration of plants together with their HQs. This result is reminiscent of what is obtained in the standard core-periphery model, but the agglomeration process is here gradual instead of being discontinuous. In other words, *in the absence of a wage differential, economic integration fosters the agglomeration of plants within the core.*

Things become more complicated when  $\phi_C > 1$  (or  $T_C/a_B < 1$ ), a situation that happens provided that the productivity of unskilled workers in the periphery is lower than in the core ( $a_B > 1$ ). Three cases may then arise. In the first one, we have

$$1 < \phi_C < \frac{1}{\sqrt{1 - (\mu/\sigma)^2}}$$

As Figure 1 shows, when trade costs decrease,  $\theta^*$  keeps rising from  $(1 + \mu/\sigma)/2$  to 1. In other words, we observe a process of gradual agglomeration of plants into the core because the forces at work in the standard core-periphery model are dominant. However, when  $\phi_M$  is very large, there is an “almost” catastrophic re-location of plants into the periphery (the  $\phi_C$ -domain over which transition occurs is very small). This is because *trade costs become so low that it is optimal for the firms to take advantage of the lower wage prevailing in region B by locating there.*

In the second case, we have

$$\frac{1}{\sqrt{1 - (\mu/\sigma)^2}} < \phi_C < \sqrt{\frac{1 + \mu/\sigma}{1 - \mu/\sigma}}$$

Again, as trade costs decrease, plants progressively agglomerate in region A until  $\theta$  reaches the value for which  $\phi_C[\phi_M(\theta); \theta] = \phi_C$  holds (i.e.,  $\phi_M$  hits the broken line in Figure 1). However, further decreases in trade costs now

lead to a gradual fall in the plant share of the core region until all plants are established in region  $B$ .

In the third case, we have

$$[(1 + \mu/\sigma)/(1 - \mu/\sigma)]^{1/2} < \phi_C$$

Then, when trade costs are prohibitive, the mass of plants concentrated in  $A$  is just equal to  $(1 + \mu/\sigma)/2$ . As trade costs start falling, more and more plants set up in the periphery until they are all clustered there (i.e.  $\phi_M$  hits the top bold line in Figure 1).

The results of this section may be summarized as follows.

**Proposition 3** *When  $T_C/a_B \geq 1$ , a steadily decrease in trade costs leads to a gradual agglomeration of plants in the core region. When  $T_C/a_B < 1$ , two subcases may arise. If  $T_C/a_B$  is not too small, a steadily decrease in trade costs leads, first, to a gradual agglomeration of plants in the core and, then, to a re-location of plants into the periphery. If  $T_C/a_B$  is sufficiently small, reducing trade costs triggers immediately the re-location process of plants into the periphery.*

## 5 The welfare analysis of globalization

It should be clear from the foregoing that the process of globalization may have very contrasted implications for the various groups of workers involved. In the sequel, we distinguish between the unskilled working in the core, the unskilled residing in the periphery, and the skilled who live in the core because all headquarters are agglomerated there. Although reducing communication and trade costs may not have the same impact on the well-being of workers, we restrict ourselves to a fall in communication costs caused by the development of the new information and communication technologies, because the way firms organize themselves is likely to be significantly affected by the level of communication costs.<sup>9</sup> As all nominal wages are constant, the welfare impact of falling communication costs is driven by the changes in regional price indices, which we now study.

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<sup>9</sup>It is worth stressing that a decrease in trade costs leading to the re-location of production facilities has similar welfare implications. Hence, to keep the analysis short, we omit this case.



For the price index of region  $A$ , using (13) we obtain

$$\frac{\partial P_A}{\partial \phi_C} = -\frac{P_A}{\sigma - 1} \frac{(1 - \theta^*)\phi_M + (1 - \phi_C\phi_M)\partial\theta^*/\partial\phi_C}{\theta^* + (1 - \theta^*)\phi_C\phi_M}$$

When there is no overseas plant ( $\theta^* = 1$ ), reducing communication costs has no impact on the price index in region  $A$ . When  $\phi_C$  rises sufficiently for  $\theta^*$  to belong to  $(0, 1)$ , the analysis is less straightforward because two opposite effects are at work. The direct effect is that varieties made in the periphery are produced at a lower unit cost because of the decreasing communication costs. The indirect effect is that more varieties are produced in the periphery, thus making them more expensive for the workers in region  $A$ . Thus, the net effect is a priori unclear. However, it turns out to be possible to show that the latter effect dominates the former. The argument goes as follows. Clearly,

$$\frac{\partial P_A}{\partial \phi_C} \leq 0 \quad \text{if and only if} \quad -\frac{\partial\theta(\phi_C, \phi_M)}{\partial\phi_C} \leq \frac{(1 - \theta)\phi_M}{1 - \phi_C\phi_M}$$

When  $\phi_C(\phi_M; 1) < \phi_C < \phi_C(\phi_M; 0)$ , some tedious calculations that make use of the identity

$$\phi_M^{-1} + \phi_M - \phi_C^{-1} - \phi_C \equiv (\phi_C\phi_M^{-1} - 1)(1 - \phi_C\phi_M)\phi_C^{-1}$$

show that

$$-\frac{\partial\theta(\phi_C, \phi_M)}{\partial\phi_C} > \frac{(1 - \theta)\phi_M}{1 - \phi_C\phi_M}$$

Therefore, we have

$$\partial P_A / \partial \phi_C > 0 \quad \text{when } 0 < \theta^* < 1 \quad (31)$$

Finally, when  $\phi_C(\phi_M; 0) \leq \phi_C$ ,  $\theta^* = 0$  and we have

$$\frac{\partial P_A}{\partial \phi_C} = -\frac{P_A}{(\sigma - 1)\phi_C} < 0 \quad \text{when } \theta^* = 0$$

For the price index of region  $B$ , using (14), it is readily verified that

$$\frac{\partial P_B}{\partial \phi_C} = -\frac{P_B}{\sigma - 1} \frac{(1 - \theta^*) - (\phi_C - \phi_M)\partial\theta^*/\partial\phi_C}{\theta^*\phi_M + (1 - \theta^*)\phi_C}$$

When  $\phi_C \leq \phi_C(\phi_M; 1)$ , we have  $\theta^* = 1$ . Observing that  $\partial\theta^*/\partial\phi_C = 0$  at  $\theta^* = 1$  and setting  $\theta^* = 1$  in the above expression, we see immediately that  $\partial P_B/\partial\phi_C = 0$  as long as  $\theta^* = 1$ . When  $\phi_C(\phi_M; 1) < \phi_C < \phi_C(\phi_M; 0)$ , we have

$$\frac{\partial\theta^*}{\partial\phi_C} = \frac{\partial\theta(\phi_C, \phi_M)}{\partial\phi_C}$$

which has been shown to be negative. Hence, we get

$$\partial P_B/\partial\phi_C < 0 \quad \text{when } 0 < \theta^* < 1$$

Finally, when  $\phi_C(\phi_M; 0) \leq \phi_C$ , we have  $\theta^* = 0$ . In this case

$$\frac{\partial P_B}{\partial\phi_C} = -\frac{P_B}{(\sigma - 1)\phi_C} < 0 \quad \text{when } \theta^* = 0$$

As said above, because nominal wages are independent of  $\phi_C$ , real wages are determined by the evolution of the price index of the **M**-good. Consider, first, the unskilled in the periphery. As long as  $\theta^* = 1$ , their real wage is unaffected by a decrease in communication costs. When  $\theta^* \in (0, 1)$ , we know that  $\partial P_B/\partial\phi_C < 0$  so that the unskilled living in the periphery are getting better off. Finally, when  $\theta^* = 0$ ,  $\partial P_B/\partial\phi_C < 0$  still holds, thus implying that the real wage of the unskilled living in *B* keeps rising. Thus, we may conclude that a fall in communication costs leave the unskilled in the periphery unaffected as long as all plants remain in the core. By contrast, when the re-location process has started, any further decrease in the communication costs always make the unskilled in the periphery better off. This should not come as a surprise. Indeed, when the communication costs fall, more and more varieties are produced in the periphery where the unit production cost of the corresponding plants decreases. Hence, the local price index must decrease.

Regarding now the unskilled in the core, when there is no overseas plant ( $\theta^* = 1$ ), reducing communication costs has no impact on the price index in region *A* and, therefore, on the well-being of the unskilled residing there. When  $\theta^* \in (0, 1)$ , we have seen that  $\partial P_A/\partial\phi_C > 0$  so that the unskilled living in the core are getting worse off. Finally, when all plants are located overseas, the unskilled living in the core benefit from further decreases in communication costs because plants operate at lower cost. As a result, the unskilled in *A* are now better off.

It remains to investigate the impact of falling communication costs on the welfare of the skilled. In fact, as their wage has been shown to be independent of  $\phi_C$ , what we have just seen about the unskilled in the core also applies to the skilled. Because the unskilled residing in the core are also worse off, we may conclude that *welfare in the core region goes down as plants move into the periphery*. Accordingly, workers living in the periphery always gain from technological innovations leading to sufficiently low transfer costs whereas skilled and unskilled workers in the core always lose from the development of such innovations. This runs against the “conventional wisdom” that claims that only the unskilled living in the core are negatively affected by the process of globalization. In addition, when the re-location process is completed, further decreases in transfer costs make everybody in the economy better off because the price index goes down in each region.

The results above are now summarized as follows.

**Proposition 4** *Assume that communication costs fall. First, all workers are unaffected when all firms remain integrated. Once some firms start re-locating their production facilities into the periphery, the skilled and unskilled in the core are worse off, whereas the unskilled living in the periphery are better off. Last, when all plants are located overseas, all workers benefit from further lowering communication costs.*

The result about the welfare of the skilled is surprising and deserves some discussion. We view the reason for it in the fact that each firm accurately neglects all general equilibrium effects because it is negligible. As each firm does the same, all firms end up, after the decrease in communication costs, in a situation in which they make real operating profits that are lower than those made before the communication costs’ decrease.

Even though it would be an artefact of the Dixit-Stiglitz model, this result suffices to say that *the skilled might also lose from going international*, whereas it is often argued in the general press that international fragmentation is one of the main reasons for the growing inequality among workers (or between workers and capital owners) in developed countries. Our analysis suggest that other reasons are to be sought to explain this growing inequality. However, our analysis shows that globalization is likely to have strong redistributive impacts, some of which are not necessarily as such expected a priori.

## 6 Concluding remarks

Globalization has at least two facets in that it goes hand in hand with lower trade costs between countries as well as with lower communication costs between HQs and plants (the economy moves in the North-East direction in Figure 1). Even though the HQs remain within the same region because of the many factors that keep them together, two very contrasted patterns must be distinguished regarding the location of plants. In the first scenario, the unskilled have about the same productivity in either region. Very much as in economic geography, market integration then fosters the gradual agglomeration of plants in the region with the initial advantage, which is here the region accommodating the HQs. In the second scenario, the productivity of the unskilled in the periphery is (significantly) lower than the productivity of the unskilled in the core. Although the process of integration might first lead to the agglomeration of more plants in the core, eventually it triggers the re-location of plants into the periphery because, once trade and communication costs have decreased sufficiently, the wage differential effect becomes predominant. These two scenarios point to the importance of having sufficiently large wage gaps for a vast multinationalization of activities to emerge as a possible outcome of globalization.

To be sure, those conclusions have been derived under very simplifying assumptions regarding the working of the labor market. First, one normally expects the labor markets for the unskilled to react when the flow of re-locations becomes significant. In this case, the process should slow down as the nominal wage of the unskilled in the periphery rises whereas the nominal wage of the unskilled in the core decreases (Krugman and Venables, 1995). However, another possible response by firms to the rise of the nominal wage in the periphery is to move their plants into a third region, namely the “periphery of the periphery”. This possibility should not be ignored, as shown by the many on-going re-locations from Mexico to China. Second, at first sight the move of non-skill-intensive activities offshore seems to favor the skilled in the core region. However, we have seen that such a move does not necessarily make these workers better off. Of course, there is nothing in our framework that allows for innovation (the number of firms and varieties are constant, whereas the new information and communication technologies generate no productivity gains in the HQs). Doing so meaningfully requires the introduction of a R&D sector in the context of an endogenous growth model, such as Fujita and Thisse (2003) in which firms are assumed to be integrated.

Extending this setting to the case of multi-unit firms is a challenging topic for future research.

## Appendix

Differentiating (21) with respect to  $\phi_C$  yields

$$\frac{\partial F}{\partial \phi_C} = -2\phi_C^{-3} \left[ \frac{1 + \mu/\sigma}{2} \phi_M^{-1} + \frac{1 - \mu/\sigma}{2} \phi_M - \phi_C \right]$$

which implies that, for any fixed value of  $\phi_M < 1$ ,  $F(\phi_C, \phi_M)$  achieves its minimum at

$$\hat{\phi}_H = \frac{1 + \mu/\sigma}{2} \phi_M^{-1} + \frac{1 - \mu/\sigma}{2} \phi_M$$

The minimum value of  $F$  is then as follows:

$$F(\hat{\phi}_H, \phi_M) = \frac{1 + (\mu/\sigma)^2 + [1 - (\mu/\sigma)^2](\phi_M^{-2} + \phi_M^2)/2 - 2}{(1 + \mu/\sigma)\phi_M^{-1} + (1 - \mu/\sigma)\phi_M}$$

which is always positive because  $\phi_M^{-2} + \phi_M^2 > 2$  when  $\phi_M < 1$ .

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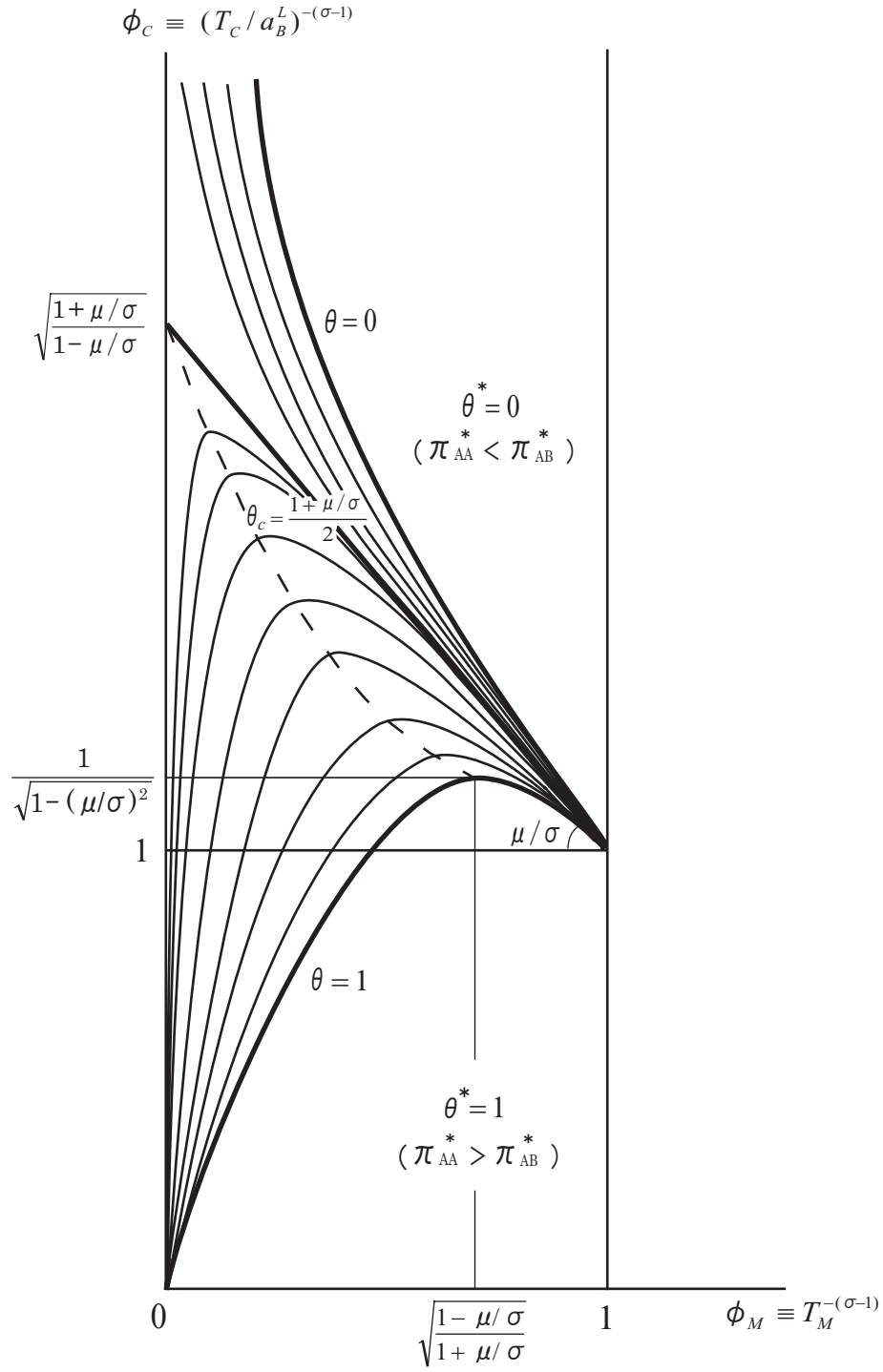


Figure 1. Iso-share curves for plant distribution